AD733141

NATIONAL RESEARCH COUNCIL OF CANADA

SPACE RESEARCH FACILITIES BRANCH

BLACK BRANT ROCKET AAF-VB-32

LAUNCHED AT CHURCHILL RESEARCH RANGE

3 MARCH 1971

Operations Requirement Number 7016

OTTAWA

October 1971

ABSTRACT

This report deals with the engineering aspects of preparing the payload and launching Black Brant rocket AAF-VB-32 at Churchill Research Range on 3 March 1971. The payload included ten experiments to measure energetic particles, auroral emissions, electron temperature and energy distribution, rotational temperatures and number densities of atomic oxygen, molecular oxygen, nitrogen and helium, ambient temperatures, electric fields and magnetic field variations, plasma characteristics, and the detection of relative speed and direction of impacting hypervelocity micrometeoroids. The vehicle performed as predicted, and good data were obtained.

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ILLUSTRATIONS

BLACK BRANT ROCKET AAF-VB-32
LAUNCHED AT CHURCHILL RESEARCH RANGE 3 MARCH 1971

The National Research Council of Canada is engaged in a sounding rocket program with various groups from Canadian universities, scientists in the Council and other agencies who are interested in performing measurements in the upper atmosphere with particular reference to auroral activity.

The program is coordinated by the Associate Committee on Space Research of the National Research Council of Canada. Payload engineering, fabrication (except for the experimenters' own equipment), checkout and launching are arranged by the Space Research Facilities Branch through contracts to various government agencies and Canadian industry.

This report deals with the launching of Black Brant rocket AAF-VB-32 at Churchill Research Range in March 1971, carrying experiments to perform the launch objectives contained in the following paragraph.

LAUNCH OBJECTIVES

Launch objectives included measurements of the intensity of energy and angular distribution of electrons and ions; auroral emissions; electron temperature and energy distribution; the number of densities of atomic oxygen, molecular oxygen, nitrogen and helium; ambient temperature; rotational temperature of nitrogen and concentrations of molecular nitrogen, oxygen and atomic oxygen; electric fields and magnetic field variations; plasma characteristics; and the detection of the relative speed and direction of impacting micrometeoroids.

EXPERIMENTS

Energetic Particle Detector (Dr. B.A. Whalen, National Research Council of Canada)

This experiment was designed to measure intensity, energy and angular distribution of electrons and ions in the energy range from 10 eV to 100 KeV.

Mark IV Auroral Scanning Photometer (Dr. C.D. Anger, University of Calgary)

This dual wavelength photometer was designed to measure auroral emissions around the rocket at 3914 Å and 5577 Å or 3914 Å and 6300 Å.

Multi-Grid Velocity Analyzer (Dr. D. Brooks, University of Montreal)

This instrument was to measure electron temperature and energy distribution of electrons in the ionosphere.

Aerodynamic Spectrometer (J. Visentin, University of Toronto)

This experiment was designed to measure the number densities of atomic oxygen, molecular oxygen, molecular nitrogen and helium, as well as the ambient temperature in the free molecular region of the upper atmosphere (100 kilometers).

Electron Beam Fluorescence Probe (Dr. J.H. deLeeuw and Mr. W.E.R. Davies, University of Toronto)

This instrument was to measure the rotational temperature of nitrogen and concentrations of molecular nitrogen, molecular oxygen and atomic oxygen.

Electric Field Probes (Dr. A. Kavadas and Dr. J.A. Koehler, University of Saskatchewan, and Dr. G. Rostoker, University of Alberta)

This experiment was designed to measure electric fields (potential difference between electrodes), currents and magnetic field variations.

Ejected Plasma Probe (Dr. A.G. McNamara, National Research Council of Canada).

The ejected plasma probe experiment was to measure plasma characteristics remote from the rocket vehicle.

Ionization Impact Detectors (Mr. R. Wlochowicz, National Research Council of Canada)

This micrometeoroid experiment was designed to detect relative speed and direction of impacting hypervelocity micrometeoroids.

DESCRIPTION OF THE VEHICLE

AAF-VB-32 was a standard Black Brant VB, single-stage, solid propellant, unguided, sounding rocket, manufactured by Bristol Aerospace (1968) Limited, Winnipeg, Manitoba. The motor was a 26KS20000 (bare metal) type, which is described in Bristol Aerospace Engineering Report No. 67533, Part II.

The motor was fitted with a standard Black Brant igniter housing and a three-fin Black Brant V stabilizer unit. Vehicle fins were aligned and dowel-pinned by the manufacturer to give a spin rate of 3.7 r/s. For this vehicle, the fins were set to produce counter-clockwise roll since a collision of one spin probe and the extended spectrometer was predicted if the normal clockwise roll direction was employed.

The nose fairing consisted of a standard Canadair Black Brant II magnesium forward body magnesium cone, modified full aluminum clamshells, 211.3 centimeters in length, and a modified Black Brant aluminum forward body. Also included were cutouts and ejectable doors to protect the payload. The fabricated aluminum forward body (with cut-outs) and an ejectable door) extended the parallel sections. Two spin probes were mounted on the outside of the fairing. All external surfaces were clean, bare metal.

General Data on the Vehicle

Length	799.3 centimeters
Diameter	43 centimeters
Launch Weight	1469.7 kilograms
Burnout Weight	469.8 Kilograms
Gross Payload Weight	240.4 kilograms - This included nose assembly, instrumentation frame, igniter and net payload.
Discharge Weight	1020.7 kilograms.
Propellant	Aluminized single grain polyurethane ammonium perchlorate

This rocket was to be launched at an effective QE of 85° to reach a minimum apogee altitude of 300 kilometers, and on an azimuth as far south as possible. However, the designed payload of 204.1 kilograms was increased to 240.4 kilograms due to weights of experiments, clamshell repairs and payload structure. For this condition, the predicted apogee for an 87° Q.E. launch was 275 kilometers.

PAYLOAD

The payload was designed and manufactured by Bristol Aerospace (1968) Limited, under contract with the Space Research Facilities Branch of the National Research Council of Canada. It was designed to carry experiments produced by the National Research Council of Canada and the Universities of Alberta, Calgary, Montreal, Toronto and Saskatchewan.

The payload, which was supported by a conventional dogbone and plate structure, was fitted into two forward bodies and a Canadair nosecone. The complete nosecone forward of station - 110 centimeters was designed to be discarded in flight exposing the electron beam fluorescence probe, the energetic particle detector and the ejected plasma probe experiments (Figure 2 and Plate 1).

Clamshell Modification

Under a supplement to the contract, tests were held at Space Engineering Division of the University of Saskatchewan, in mid-December 1970 to confirm acceptable clamshell deployment from a spinning (3.7 cps) vehicle. Catastrophic impact with the payload and energetic particle detector mock-up occurred, and the flight clamshells were damaged during the tests. Subsequent repairs, mechanical and logic modifications were tested successfully on 17 January 1971. Bristol Aerospace (1968) Limited later replaced the clamshell bolt with a stronger, easier to cut, swaged cable and nut assembly. Bristol Aerospace also added a backup sequencing function to cut the cable if the manacle ring was not released, and an annular wedge around the cone base to protect the protruding manacle ring from aerodynamic heating.

Six types of pyrotechnic actuators (squibs) were used in the ejection/extension of spin probe shrouds, auroral scanner, ejected plasma probe, experiment doors clamshells, ionization impact detectors, electron beam fluorescence probe and the two spin probes.

No transponders or beacons were used in this vehicle.

TELEMETRY

Data from the experiments were transmitted by five separate transmitters, one PCM/FM and one FM/FM telemetry systems with nominal transmitter powers of four and five watts respectively in the vehicle, and three low-power systems in the ejected packages.

Vehicle Telemetry

Link Number 1 - This was primary telemetry, a PCM/FM system operating at a frequency of 240.2 MHz with standard quadraloop radiators providing linear polarization spaced 180° apart on the igniter housing.

PCM format was word length 3 bits, frame sync word length 6 bits, words/frame 22; 400 frames per second. Bit rate was 26.4 K bits per second. One PCM encoder was employed.

Link Number 2 - This was also primary telemetry. It was an FM/FM link operating at a frequency of 219.5 MHz with an antenna system consisting of two linearly polarized quadraloop radiators spaced 180° apart in the same location as the Link No. 1 array.

Eight subcarriers were employed on this link, using IRIG bands 7, 9, 11, 12, 13, 18, 19, and 21, with modulation as described below.

Link Number 2 Subcarrier Oscillator Allocations

IRIG Band	Center Frequency kHz	Information
7	2.3	Experiment #3 BAL
9	3.9	Experiment #3 Log DC
11	7.35	Experiment #5 Photomultiplier
12	10.5	Experiment #3 log AC
13	14.5	Experiment #4 AC output
18	70.0	10 x 30 Commutator #2
19	93.0	20 x 30 Commutator #1
21	165.0	Auroral scanner output

Deviation on all bands was ± 7.5%.

One 10 x 30 and one 20 x 30 commutator and one sub-commutator were used. Assignments are shown in Tables 2, 3 and 4 respectively.

Ejected Package Telemetry

Links Number 3 and 4 - These were the electric field experiment telemetry transmitters, which were contained in the two spin probes. The probes were employed to measure electric and magnetic field variations, with the probes to be released in flight.

Each probe contained its own FM/FM transmitter operating on the frequencies 228 and 229 MHz respectively, with a nominal power of 60 to 100 milliwatts.

Links No. 3 and 4 used two subcarrier oscillators each, one on IRIG band 14 with a center frequency of 22.0 kHz the other, non-standard with a center frequency of 15.7 kHz.

Subcarrier deviation on both links was ± 7.5%.

Link Number 5 - This was the ejected plasma probe, which also contained its own FM/FM transmitter operating at a frequency of 227.02 MHz, with a nominal power of 200 milliwatts.

Two subcarrier oscillators were used, employing IRIG bands 11 and 12 with a center frequency of 7.35 and 10.5 kHz respectively. These were used to convey signal and sweep data.

Subcarrier deviation was 7.5%.

RANGE SUPPORT

General

The range was requested to provide close liaison with the Space Engineering Division of the University of Saskatchewan for Links 3 and 4 at the Saskatoon receiving station.

The scientists' observation tower was to be heated and ready for use.

During the pre-flight conference, the project scientist was to confirm requirements of all-sky camera with fish-eye lenses, the riometer and three axes magnetometer.

Ground-based auroral support measurements were to be done with a spiral scanner measuring 2 feet by 2 feet by 4 feet, supplied by the experimenter. The scanner was to be located in the auroral observatory and placed on a pedestal a few feet off the ground and placed about 60 feet from the building. The associated electronics would require the equivalent of two racks or about six feet of bench space. Power requirements were 115 volts AC and 15 amps. Transportation for equipment to and from the observatory was required.

During the launch phase, payload temperature was to be held between 15° and 21° C.

Telemetry requirements could be met with primary and backup facilities as shown in Figures 4 and 5 - Primary and Backup Ground Telemetry Diagrams. Predetection recordings were required for Links No. 3, 4 and 5, the ejected package telemetry systems. In-flight frequency and signal strengths for all telemetry links were to be recorded.

Details of Ground Support Telemetry Equipment

Ejected Plasma Probe - Conversion kits for the two NC 1433 receivers are supplied to Churchill Research Range. These kits consist of crystals to produce a 5 MHzIF signal and a connector to provide a 5 MHz output terminal.

Two crystal-controlled down-converters are supplied to CRR for use at main T/M and at backup T/M. The center frequency of the pre-detection output is 80 kHz, with a bandwidth of ± 20 kHz. These units include the necessary filters and adders to combine the pre-detection ignal and the FM video for recording on a single track of the tape recorder.

The signal strength of the transmitter is monitored via the AGC voltage of a receiver. An IF bandwidth of 100 kHz is optimum for this purpose. This record provides tumble rate and information on the aspect of the ejected package.

Laboratory and pre-flight checkout of the package can be performed using any standard FM receiver and 10.5 kHz and 7.35 kHz discriminators.

NRC down-converters have been supplied to CRR* Telemetry Section, together with an assortment of crystals by SRFB and REED.* Nems Clarke 1432 receivers modified for use with these converters will be provided by SRFB.

Spin Probe Experiment - The pre-detection recording scheme essentially consists of a Nems Clarke 1037 receiver equipped with a down-converter, which translates the carrier center frequency to 112.5 kHz for recording on the magnetic tape. Note that two such receivers will be required, one for each probe. It is presumed that CRR will provide the necessary antennas, receivers and tape handling facilities as in the past. SRFB will provide suitable down-converters (NC DNC-301) to CRR for this recording.

*CRR-Churchill Research Range; REED-Radio and Electrical Engineering Division.

Recordings

Three separate magnetic tape recordings were required, recording the following:

Magnetic Tape No. 1

Track	DATA
1	IRIG "B" timing wave form
2	Station multiplex
3	Telemetry Link No. 1 (219.5 MHz) FM record, center frequency 108 kHz ±40%

Track	Data
4	100 kHz reference sinusoid
5	Telemetry Link No. 2 (240.2 MHz)
6	Telemetry Link No. 5 (227.0 MHz) pre-detection and video
7	Reference sinusoids and voice countdown

Magnetic Tape No. 2

Track	Data
1	Telemetry Link No. 3 video
2	Telemetry Link No. 3 pre-detection recording
3	
4	100 kHz reference sinusoid
5	
6	Station multiplex
7	Voice countdown

Magnetic Tape No. 3

Track	Data
1	Telemetry Link No. 4 video
2	Telemetry Link No. 4 pre-detection recording
3	
4	100 kHz reference
5	
6	Station multiplex*
7	Voice countdown

*Station multiplex was to be arranged as follows:

IRIG	Frequency kHz	Data
9	3.9	AGC Link No. 1 (219.5 MHz)
10	5.4	AGC Link No. 2 (240.2 MHz)
11	7.35	AGC Link No. 3
12	10.5	Tape servo reference of 17.0 kHz sinusoid 50% amplitude modulated by 60 Hz square wave
13	14.5	AGC Link No. 5 (tri-helix)
14	22.0	AGC Link No. 5 (users Yagi antenna)
15	30.0	IRIG "C" timing wave form
16	40.0	AGC Link No. 1 (219.5 MHz) tri-helix
17	52.5	AGC Link No. 2 (240.2 MHz) tri-helix
18	70.0	IRIG "B" timing waveform with lift-off tone

Required Frequency Response:	300 Hz to 300 kHz
Tape Speed:	60 in/sec
Duration:	T-2 minutes to impact (about 10 minutes, excluding time for signal strength calibration after impact). The tape was also run briefly during horizontal checks to record experiment calibrations.

Tracking

Radar skin tracking of the vehicle was to provide positional data of H vs. R and X vs. Y at one data point per second on the up and down legs of the trajectory and one data point every 5 seconds over apogee.

Filming of the range gate was required at 6 frames per second from T-0 to T+90 seconds.

LAUNCH REQUIREMENTS

This was a single-vehicle project, with the launching to take place at night during an auroral breakup with a negative bay. The first attempt was scheduled for 2145 central standard time, 16 February 1971, with night-to-night rescheduling required to meet the desired geophysical launch conditions.

LAUNCH PREPARATIONS

The pre-flight meeting was held during the afternoon of Friday, 19 February. Details of experiments, Test Directive and the Operations Requirement were reviewed and the following agreed on.

Notwithstanding that trajectory data had been produced for a QE of 87°, the requirement was for an elevation of 85°. The meeting was advised that approval to use a 2 Sigma impact dispersion had been received from the Space Research Facilities Branch. Azimuth settings were not critical, and the range agreed to provide settings suitable to the experimenter. The range would also calculate a family of settings (northeast and southeast quadrant) for each pibal run.

Discussions of allowable temperature tolerance of the payload resulted in a requirement of 15.5° C plus or minus 5°. The fish-eye lenses for the all-sky camera could not be provided. In-flight frequency readouts were also not available, due to the complexity of the telemetry support required for this rocket and the

Boosted ARCAS vehicle. Frequency readouts would, however, be provided during vertical checks.

LAUNCHING

Preliminary checks were completed on Monday, 22 February, and AAF-VB-32 payload was mated to the motor on Pad 1, the Universal launcher. Heavy, overcast wind conditions and lack of the required event made launch impossible until Wednesday, 3 March. The vehicle was launched into an event of major proportions at 0052 central standard time under ideal conditions.

LAUNCH RESULTS

General

AAF-VB-32 was launched into the required conditions at 0052:11 central standard time on 3 March 1971. The vehicle performed well. Final vehicle roll rate was 3.1 r/s. Payload systems appeared to work satisfactorily with events occurring at the prescribed time. Event monitors, with the exception of the spectrometer turn monitor and M.M. extension monitor, functioned as expected. The micrometeoroid experiment appeared to experience interference at various portions of the flight, and there may have been a loss of the scanner sync pulse for part of the flight. All other experiments appeared to work satisfactorily.

Tracking

One range radar and a Mark 51 optical tracking were used during the flight of this vehicle. Track was acquired on the up-leg at T+11 seconds at a height of 1.84 kilometers. The target was lost at T+185 seconds at a height of 145 kilometers, still on the up-leg. The vehicle was reacquired on the down-leg at T+580 seconds at a height of 3.6 kilometers and tracked to impact at T+585 seconds.

Trajectory

From the radar plots furnished by the range, it was estimated that AAF-VB-32 attained an apogee of 273.6 kilometers at T+264 seconds. Vehicle height with respect to time is shown in Figure 6.

Telemetry

Telemetry reported a good signal on Links 1 and 2 throughout the flight until loss of signal at T+498 seconds. Link 3 was fair to good throughout the flight until loss of signal at T+695 seconds. Link 4 signal was acquired at

T+50 seconds, and a weak signal was received throughout the flight until loss of signal at T+510 seconds. Link 5 was noisy throughout the flight until loss of signal at T+498 seconds.

EXPERIMENT RESULTS

Energetic Particle Detector

Initial inspection of the data indicates that the experiment functioned properly and that a good telemetry signal was received throughout the flight.

Mark IV Auroral Scanner

The auroral scanner malfunctioned at lift off. Intermittent rotating mechanism prevented the scanner from making overlapping scans in elevation as it was rotated through azimuth by the rocket. Some data were obtained but will require a great deal of processing.

Multi-grid Velocity Analyser

Throughout the flight the differentiating signal channel was inoperative due to an internal instrumental malfunction, probably a lack of r.f. modulation signal. The integrating channel functioned normally except for modulation from the rocket rotation. Unfortunately, it is from the differentiating channel that the more reliable electron temperatures are derived. Saturation again occurred (for the second time) on the retarding potential monitor trace. This appears to be a telemetry problem.

Aerodynamic Spectrometer

This experiment performed within the design parameters. However, the signals were much higher than anticipated, analysis was not possible. The intense auroral activity was undoubtedly responsible for a large portion of the spurious background signal and the experiment has now been modified tc minimize this effect.

Electron Beam Fluorescence Probe

This experiment performed extremely well; the results have been reduced showing viable measurements can be made using this technique even in the presence of intense optical aurora. Molecular oxygen only was recorded on the atomic oxygen channel; this null result will require a new wavelength region to be selected following laboratory analysis.

Electric Field Probes

The telemetry was good to the Saskatoon ground station. The Churchill telemetry was poor.

The majority of the data has been processed but not analyzed yet.

Ejected Plasma Probe

The ejected plasma probe carried in this rocket was turned on in flight and appeared to be radiating at normal RF power levels. However, telemetry records and AGC monitors show that the crystal oscillator appears to have lost control of the transmitter frequency at T+69 seconds, a few seconds after ejection. As a result, all signal modulation on the carrier was lost from that time on It did not recover at any later time during the flight.

Ionization Impact Detectors

The two similar units flown on this vehicle operated throughout the flight. One unit, set for higher gain, produced no useful data due to interference, most probably RF in nature. The other unit was plagued by interference till T+185 seconds and then operated normally for the remainder of the flight. During the period of normal operation two groups of events were recorded, the meaning of which has not yet been established.

REMARKS

A Boosted ARCAS was launched at T+20 seconds into the Black Brant VB flight in conjunction with the Energetic Particle Experiment.

The aerodynamic spectrometer experimenters attributed the turn monitor failure to an experiment problem and were sure the experiment had turned as indicated by in-flight experiment operation.

Failure of the micrometeoroid deployment monitor was probably due to improper adjustment of extension monitor. It had to be adjusted with payload spinning to fully extend the experiment. Squib monitors indicated the experiment should have deployed.

For operational reasons the rocket was purposely launched at an effective QE of 85°, not 87° as planned. Achieved apogee altitude was, therefore, slightly lower than predicted, and achieved impact range was substantially larger than predicted.

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METEOROLOGICAL/IMPACT PREDICTION TEST SUMMARY AAF-VB-32

1. Test Number: 43.1B57016-7L   Support: NRC/Universities of Alberta, Calgary, Montreal, Toronto and Saskatchewan

2. Date: 3 March 1971   Scheduled Time: Launch Time: 0052 CST

3. Vehicle Type: Black Brant VB   Objective: To measure intensity and angular distribution of electrons and ions in the energy range from 10 eV to 100 KeV, auroral emissions, electron temperature and energy distribution, number densities of atomic oxygen, molecular oxygen, nitrogen and helium, ambient temperatures, electric fields and magnetic field variations, plasma characteristics and impacting micrometeoroids.

4. Motor No.: BAW-MV-57   Weight: 1229.3 kgs   Length: 478 cms

   Payload Serial No.: AAF-VB-32   Weight: 240.4 kgms.
   Length: 321.3 cms.

   Total Vehicle Weight: 1469.7 kgs.   Total Vehicle Length: 799.3 cms.

5. Surface Weather Observation:

   Surface wind 155° at 15 knots
   Temperature -21.1° C.
   Pressure 1014.6 mbs
   Visibility 15 miles - Sky conditions 20,000 feet thin and scattered

6. Vehicle Performance Predicted

Sustainer impact azimuth 111.0°	Range 155 km	Time T+536 seconds
Apogee altitude - 262 kms	Range 78.5 km	Time T+272 seconds

7. Vehicle Performance Actual

Sustainer impact azimuth 095.5°	Range 190.7 kms	Time T+585 seconds
Apogee altitude 273.6 kms	Range 102.0 kms	Time T+264 seconds

TABLE 1

LINK #2

10 x 30 COMMUTATOR #2 CHANNELS

Channel	Information: Supercommutated	Commutated	Subcommutated
1		0 volts calibration	
2		5 volts calibration	
3	X-axis magnetometer		
4	Y-axis magnetometer		
5		Squib current monitor #1	
6		Squib current monitor #2	
7		Squib current monitor #3	
8		Squib current monitor #4	
9		Link #2 monitor	
10		MM extension monitor	
11		Clamshell release monitor	
12		MM1 and MM2 door monitor and BP1 monitor	
13	X-axis magnetometer		
14	Y-axis magnetometer		
15		Manacle monitor	
16		Auscan EHT monitor	
17		Auscan temperature monitor	
18		Auscan extension monitor	
19		Experiment 3 entre monitor	
20		Experiment 3 HF monitor	
21		VA & spectrometer door monitor and BP2 monitor	
22		Spin probe motor monitor	
23	X-axis magnetometer		
24	Y-axis magnetometer		
25		Experiment 9 data plus monitor (O/P #1)	
26		Experiment 9 data plus monitor (O/P #2)	
27		Experiment 9 data plus monitor (O/P #3)	
28		EJPP RF & eject monitor	
29) 30)	Synchronization		

TABLE 2

LINK #2

20 x 30 COMMUTATOR #1 CHANNELS

Channel	Supercommutated	Commutated	Subcommutated
1		0 volts calibration	
2		5 volts calibration	
3		Experiment 1 monitor A	
4		Experiment 1 monitor B	
5		Experiment 1 monitor C	
6		Experiment 1 monitor D	
7		Experiment 1 monitor E	
8		Experiment 1 monitor F	
9		Experiment 1 monitor G	
10		Experiment 1 monitor H	
11		Experiment 8 data plus monitor (O/P #1)	
12		Experiment 8 data plus monitor (O/P #2)	
13		Experiment 8 data plus monitor (O/P #3)	
14		Experiment 4 DC output	
15		Experiment 4 range monitor	
16		Experiment 4 beam monitor	
17		Thermistor	
18		Experiment 1 monitor A	
19		Experiment 1 monitor B	
20		Experiment 4 turn monitor	
21		Zero volts	
22		Experiment 5 logging temperature	
23		Experiment 5 beam monitor	
24			Subcommutator
25			Subcommutator
26		Experiment 9 data plus monitor (O/P #1)	
27		Experiment 9 data plus monitor (O/P #2)	
28		Experiment 9 data plus monitor (O/P 3#)	
29) 30)	Synchronization		

TABLE 3

LINK #2

SUBCOMMUTATOR CHANNELS

Channel	Information
1	Empty
2	Spin probe battery monitor
3	Spin probe A high temperature thermistor
4	Spin probe A low temperature thermistor
5	Spin probe B high temperature thermistor
6	Spin probe B low temperature thermistor
7	Spin probe A shroud monitor
8	Spin probe B shroud monitor
9	Spin probe A probe eject monitor
10	Spin probe B probe eject monitor
11	Zero volts
12	Zero volts
13	+ 28 volt battery monitor BP #7
14	+ 26 volt battery monitor BP #4
15	- 20 volt battery monitor BP #5
$16\frac{1}{2}$	- 9 volt battery monitor BP #3
17	+ 4. 3 volt battery monitor BP #6
18	+ 22 volt battery monitor BP #9
19	Zero volts
20	5 volt calibration
21	5 volt calibration

TABLE 4

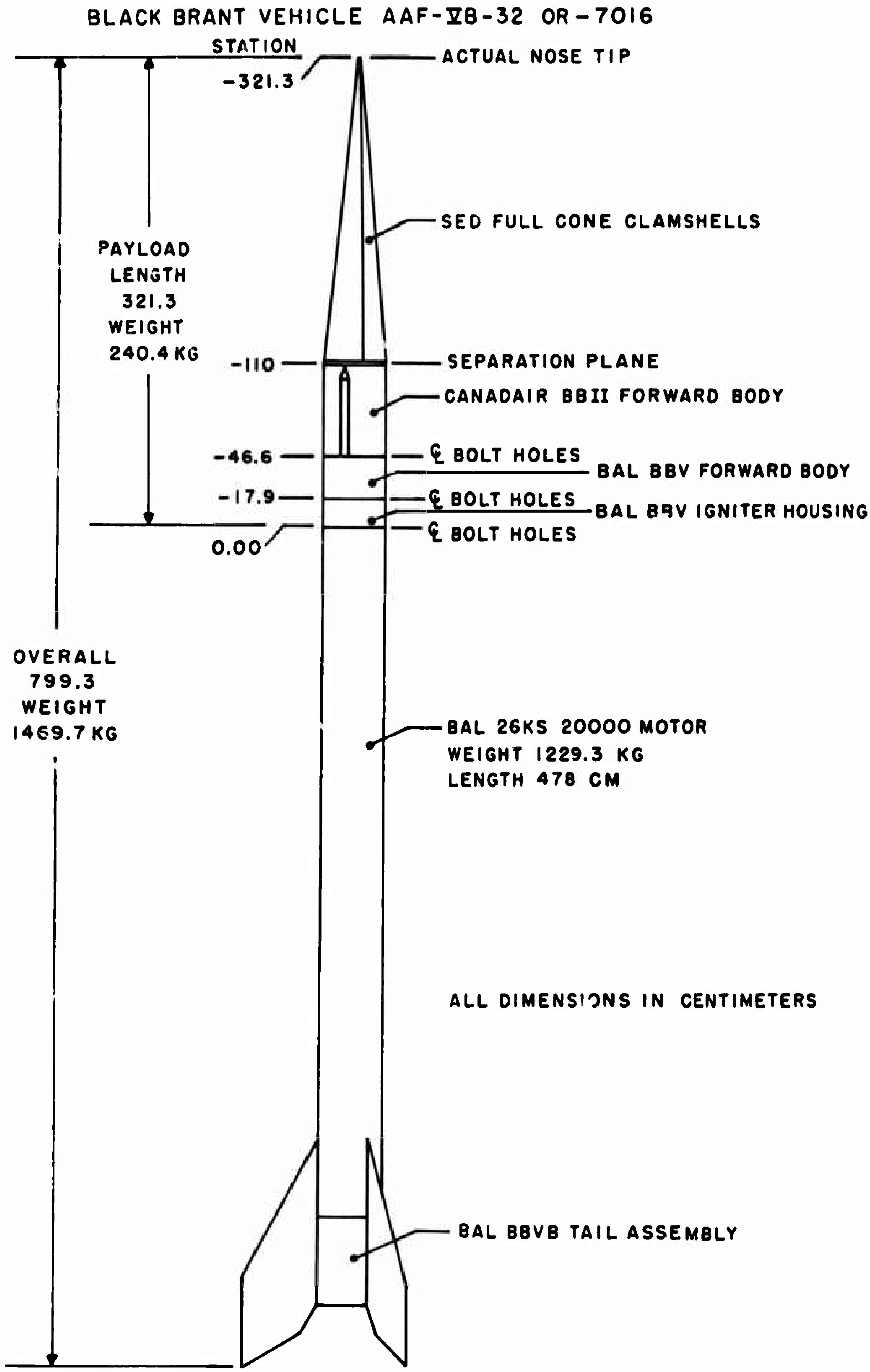
BLACK BRANT VEHICLE AAF-VB-32 OR-7016
STATION
-321.3
ACTUAL NOSE TIP
SED FULL CONE CLAMSHELLS
PAYLOAD
LENGTH
321.3
WEIGHT
240.4 KG
-110
SEPARATION PLANE
CANADAIR BBII FORWARD BODY
-46.6
℄ BOLT HOLES
BAL BBV FORWARD BODY
-17.9
℄ BOLT HOLES
BAL BBV IGNITER HOUSING
0.00
℄ BOLT HOLES
OVERALL
799.3
WEIGHT
1469.7 KG
BAL 26KS 20000 MOTOR
WEIGHT 1229.3 KG
LENGTH 478 CM
ALL DIMENSIONS IN CENTIMETERS
BAL BBVB TAIL ASSEMBLY

FIGURE I

BLACK BRANT PAYLOAD AAF-VB-32 OR -7016

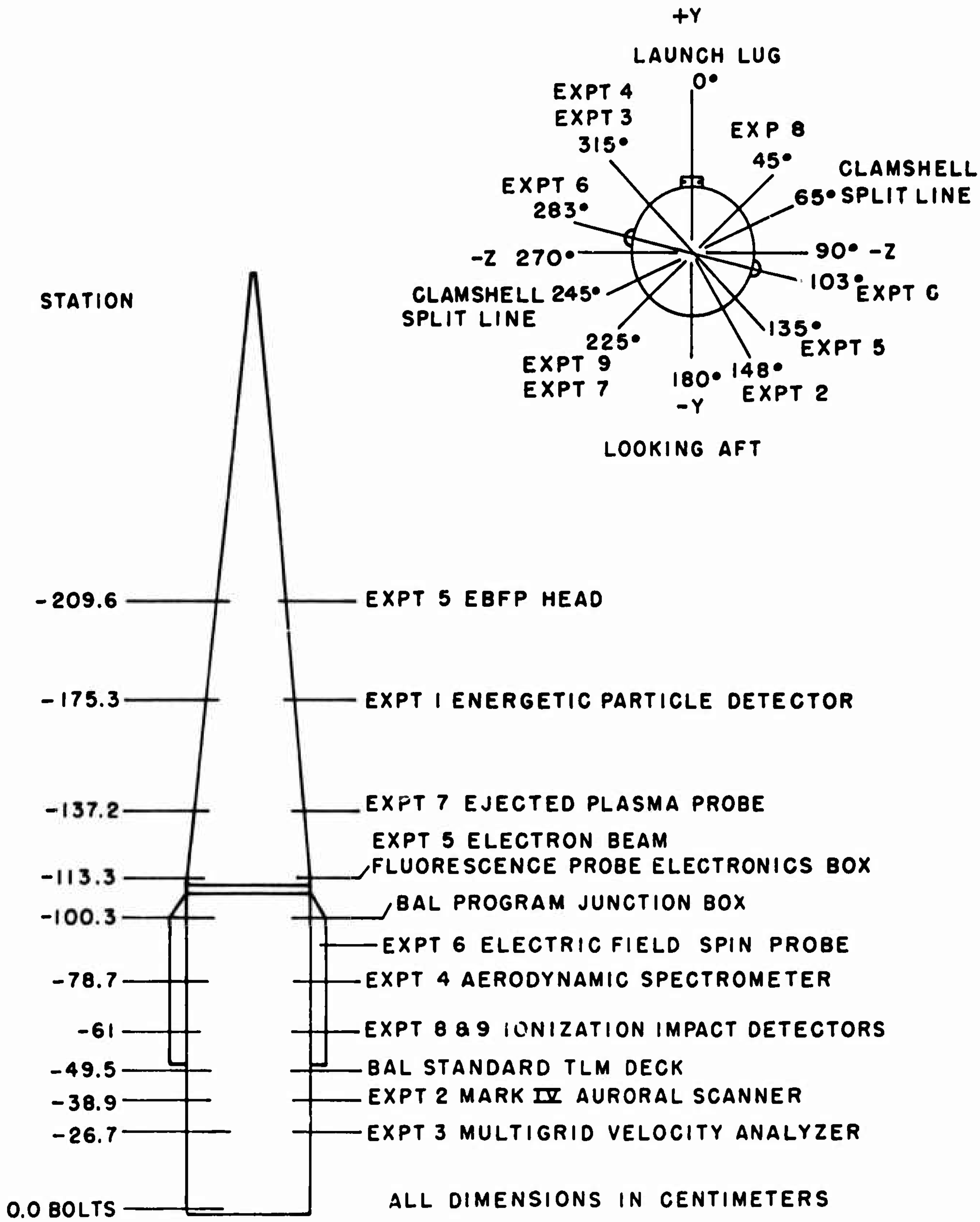

FIGURE 2

PYROTECHNIC POSITIONS

AAF-VB-32 OR-7016

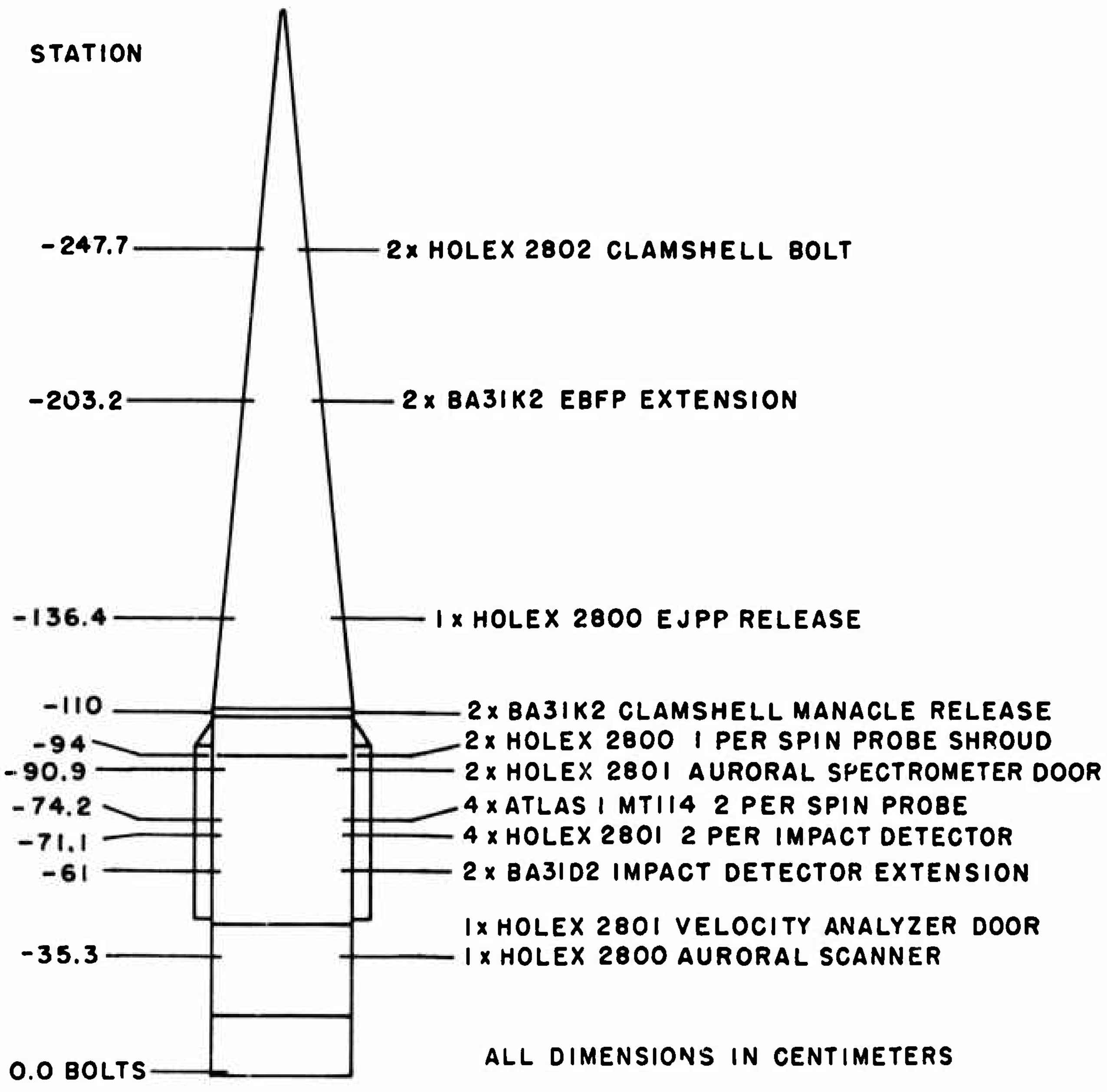

FIGURE 3

PRIMARY TELEMETRY GROUND STATION AAF-VB-32

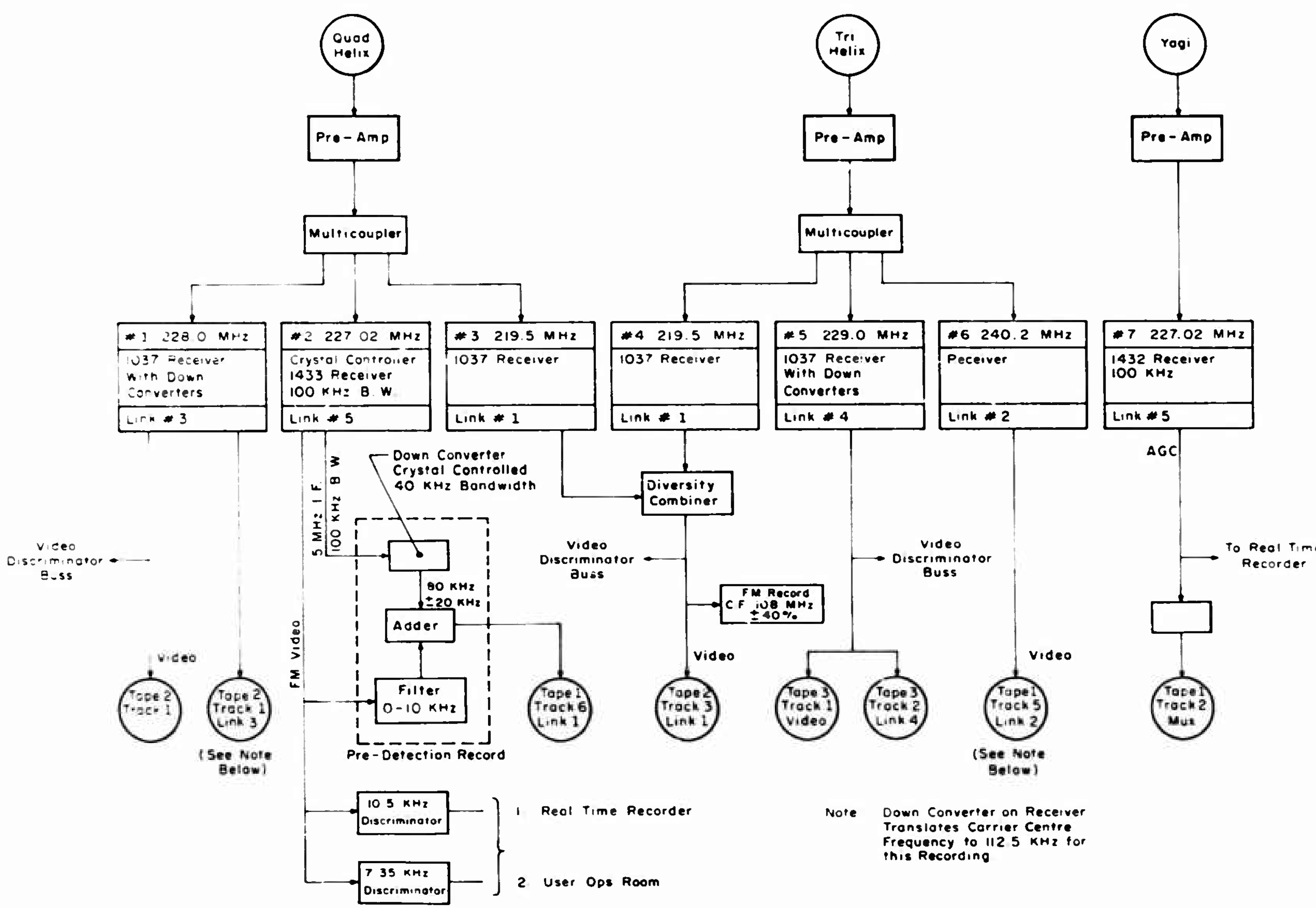

FIGURE 4

BACK-UP TELEMETRY GROUND STATION AAF-VB-32

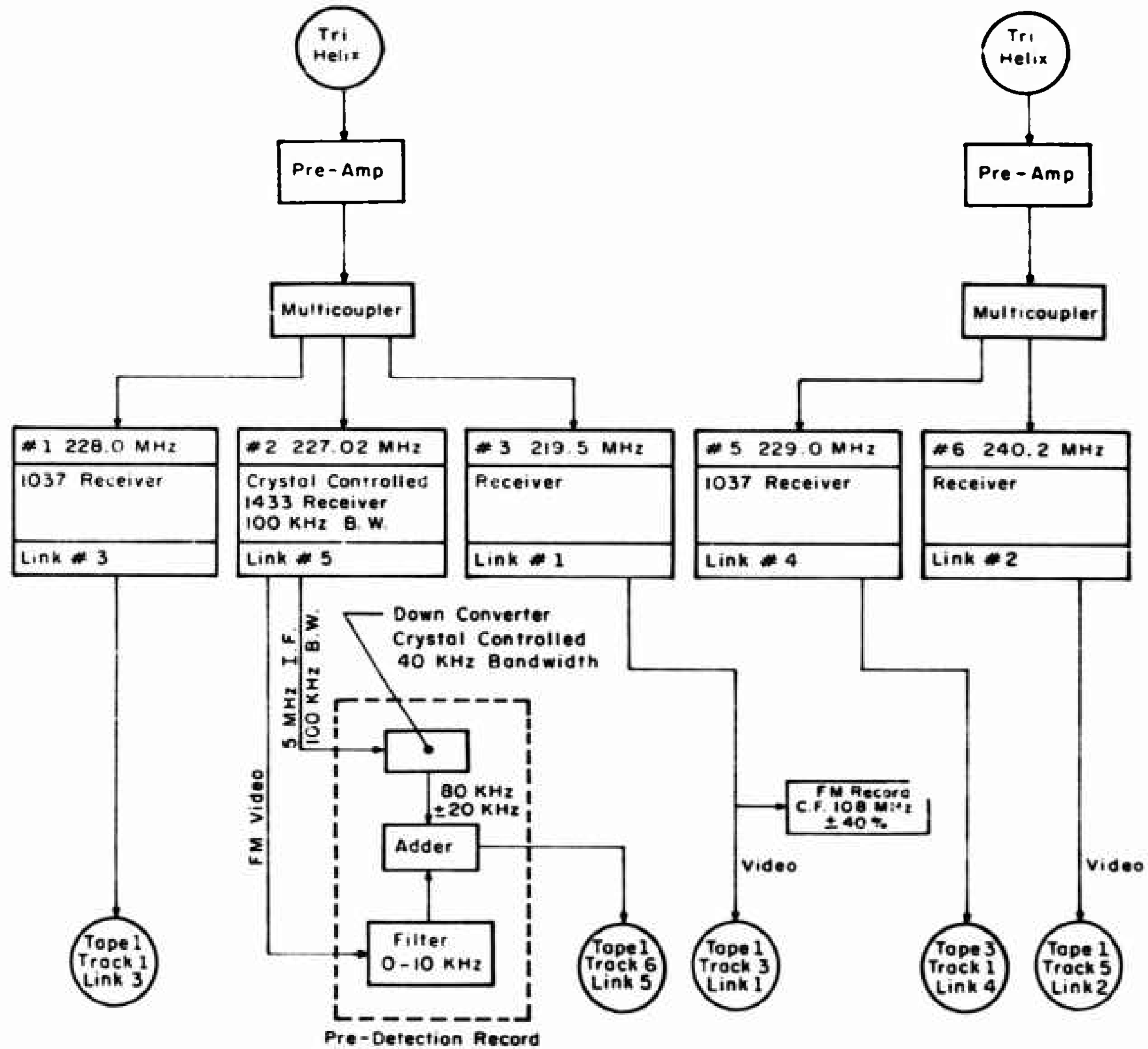

FIGURE 5

TRAJECTORY AAF-VB-32

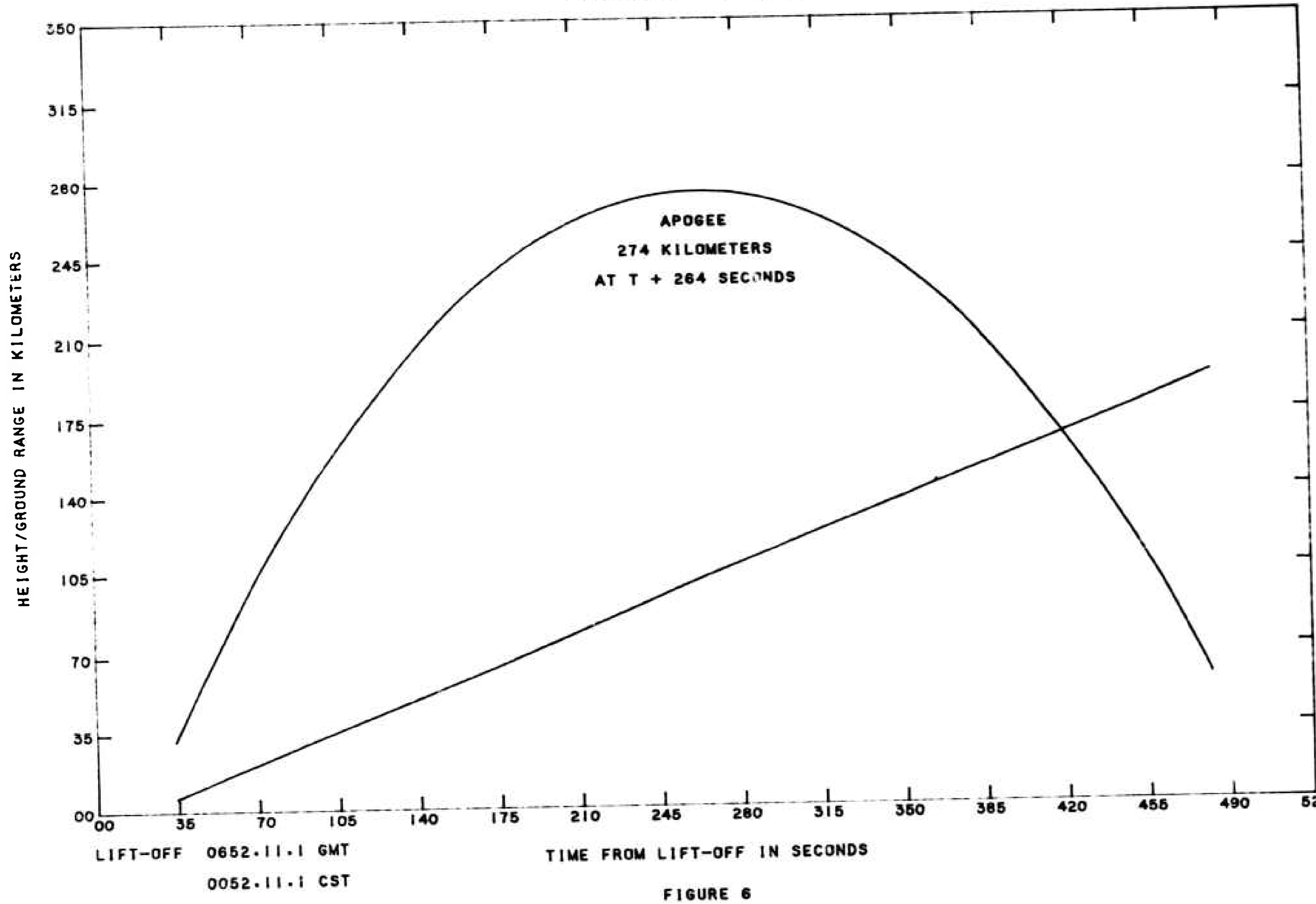

FIGURE 6

PAYLOAD WITH FAIRING REMOVED

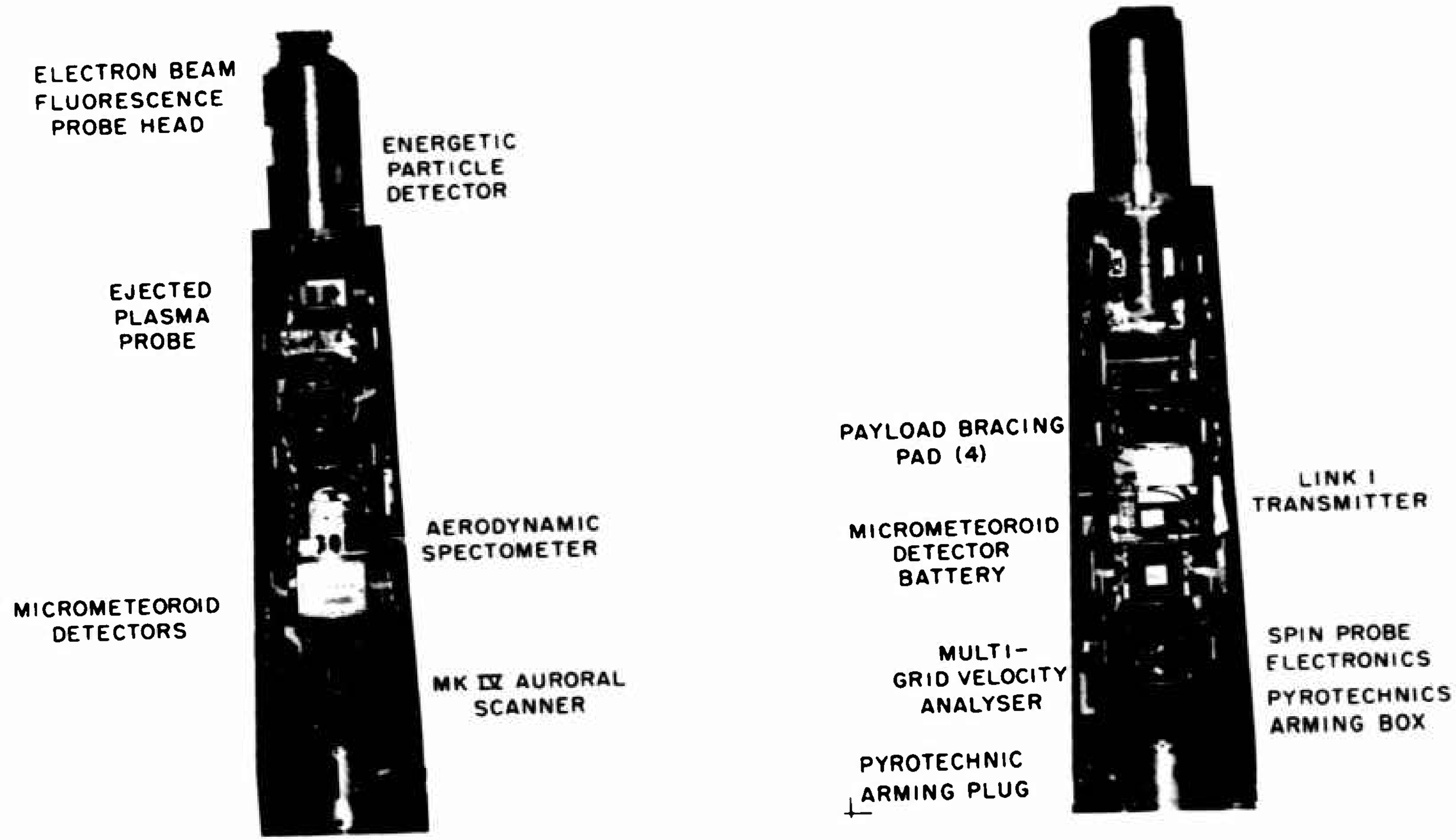

PLATE I

PAYLOAD WITH FAIRING IN PLACE

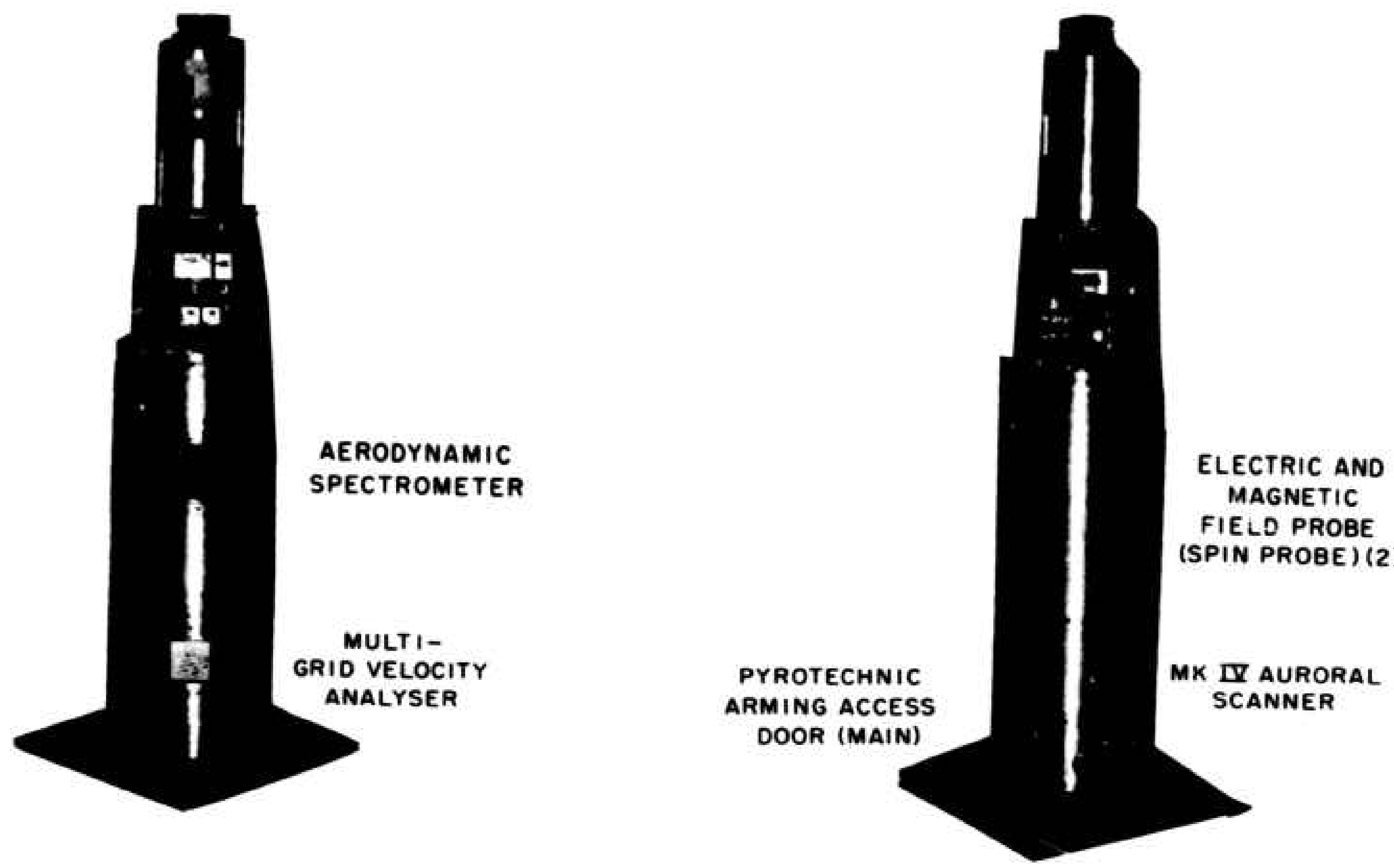

PLATE 2